CLAIMS

1. A trending system for trending performance in an mechanical system, the trending system comprising:

   a performance estimator, the performance estimator receiving sensor data and generating performance parameter estimates for the mechanical system; and

   a predictive trending mechanism, the predictive trending mechanism receiving the performance parameter estimates and determining an estimated trend for the performance parameters through monotonic regression of the performance parameter estimates.

2. The system of claim 1 wherein the estimated trend determined by the predictive trending mechanism includes a filtered estimate of the performance parameter.

3. The system of claim 1 wherein the estimated trend determined by the predictive trending mechanism includes a prediction of future performance parameters.

4. The system of claim 1 wherein the predictive trending mechanism comprises a quadratic programming problem solver.

5. The system of claim 1 wherein the predictive trending mechanism performs a first order monotonic regression analysis through imposing a linear constraint of a monotonic data change in a quadratic programming problem.

6. The system of claim 1 wherein the predictive trending mechanism performs a second order monotonic regression analysis, the second-order monotonic regression analysis determining an estimated trend for a primary fault condition and an estimated trend for secondary damage accumulating because of this primary fault condition.

7. The system of claim 6 wherein the predictive trending mechanism performs the second order monotonic regression analysis through imposing a linear constraint of a monotonic trend rate change reflecting the primary fault condition and a linear constraint of the monotonic data change reflecting the secondary fault condition in a quadratic programming problem.

8. The system of claim 1 wherein the predictive trending mechanism includes at least one tuning parameter selected to achieve a desired tradeoff in noise rejection and data following performance for the estimated trend.

9. The system of claim 1 wherein the performance estimator generates the performance parameter estimates for the mechanical system from sensor data residuals.

10. The system of claim 9 wherein the performance estimator generates the sensor data residuals by using a predictive model of the mechanical system.

11. A method of trending performance in a mechanical system, the method comprising the steps of:

    a) receiving sensor data from the mechanical system;

    b) generating performance parameter estimates for the mechanical system from the received sensor data; and

    c) determining an estimated trend for the performance parameter through monotonic regression of the performance parameter estimates.

12. The method of claim 11 wherein the estimated trend includes a filtered estimate of the performance parameter.

13. The method of claim 11 wherein the estimated trend includes a prediction of future performance parameters.

14. The method of claim 11 wherein the step of determining an estimated trend for the performance parameter through monotonic regression of the performance parameter estimates comprises determining the estimated trend with a quadratic programming problem solver.

15. The method of claim 11 wherein the step of determining an estimated trend for the performance parameter through monotonic regression of the performance parameter estimates comprises a first order monotonic regression analysis through imposing a linear constraint of a monotonic data change in a quadratic programming problem.

16. The method of claim 11 wherein the step of determining an estimated trend for the performance parameter through monotonic regression of the performance parameter estimates comprises a second order monotonic regression analysis, the second-order monotonic regression analysis determining an estimated trend for a primary fault condition and an estimated trend for secondary damage accumulating because of this primary fault condition.

17. The method of claim 16 wherein the second order monotonic regression analysis is performed through imposing a linear constraint of a monotonic trend rate change reflecting the primary fault condition and a linear constraint of the monotonic data change reflecting the secondary fault condition in a quadratic programming problem.

18. The method of claim 11 wherein the step of determining an estimated trend for the performance parameter through monotonic regression of the performance parameter estimates comprises selecting at least one tuning parameter to achieve a desired tradeoff in noise rejection and trend following performance.

19. The method of claim 11 wherein the step of generating performance parameter estimates for the mechanical system from the received sensor data comprises generating residuals from the received sensor data.

20. The method of claim 19 wherein the step of generating residuals from the received sensor data comprises comparing the sensor data to expected sensor values by using a predictive model.

21. A program product comprising:

a) a trending program, the trending program including:

a performance estimator, the performance estimator receiving sensor data and generating performance parameter estimates for the mechanical system; and

a predictive trending mechanism, the predictive trending mechanism receiving the performance parameter estimates and determining an estimated trend for the performance parameters through monotonic regression of the performance parameter estimates; and

b) signal bearing media bearing said trending program.

22. The program product of claim 21 wherein the signal bearing media comprises recordable media.

23. The program product of claim 21 wherein the signal bearing media comprises transmission media.

24. The program product of claim 21 wherein the estimated trend determined by the predictive trending mechanism includes a filtered estimate of the performance parameter.

25. The program product of claim 21 wherein the estimated trend determined by the predictive trending mechanism includes a prediction of future performance parameters.

26. The program product of claim 21 wherein the predictive trending mechanism comprises a quadratic programming problem solver.

27. The program product of claim 21 wherein the predictive trending mechanism performs a first order monotonic regression analysis through imposing a linear constraint of a monotonic data change in a quadratic programming problem.

28. The program product of claim 21 wherein the predictive trending mechanism performs a second order monotonic regression analysis, the second-order monotonic regression analysis determining an estimated trend for a primary fault condition and an estimated trend for secondary damage accumulating because of this primary fault condition.

29. The program product of claim 28 wherein the predictive trending mechanism performs the second order monotonic regression analysis through imposing a linear constraint of a monotonic trend rate change reflecting the primary fault condition and a linear constraint of the monotonic data change reflecting the secondary fault condition in a quadratic programming problem.

30. The program product of claim 21 wherein the predictive trending mechanism includes at least one tuning parameter selected to achieve a desired tradeoff in noise rejection and data following performance for the estimated trend.

31. The program product of claim 21 wherein the performance estimator generates the performance parameter estimates for the mechanical system from sensor data residuals.

32. The program product of claim 31 wherein the performance estimator generates the sensor data residuals by using a predictive model of the mechanical system.

33. An apparatus comprising:

a) a processor;

b) a memory coupled to the processor;

c) a trending program residing in the memory and being executed by the processor, the trending program including:

i) a performance estimator, the performance estimator receiving sensor data and generating performance parameter estimates for the mechanical system; and

ii) a predictive trending mechanism, the predictive trending mechanism receiving the performance parameter estimates and determining an estimated trend for the performance parameters through monotonic regression of the performance parameter estimates.

34. The apparatus of claim 33 wherein the estimated trend determined by the predictive trending mechanism includes a filtered estimate of the performance parameter.

35. The apparatus of claim 33 wherein the estimated trend determined by the predictive trending mechanism includes a prediction of future performance parameters.

36. The apparatus of claim 33 wherein the predictive trending mechanism comprises a quadratic programming problem solver.

37. The apparatus of claim 33 wherein the predictive trending mechanism performs a first order monotonic regression analysis through imposing a linear constraint of a monotonic data change in a quadratic programming problem.

38. The apparatus of claim 33 wherein the predictive trending mechanism performs a second order monotonic regression analysis, the second-order monotonic regression analysis determining an estimated trend for a primary fault condition and an estimated trend for secondary damage accumulating because of this primary fault condition.

39. The apparatus of claim 38 wherein the predictive trending mechanism performs the second order monotonic regression analysis through imposing a linear constraint of a monotonic trend rate change reflecting the primary fault condition and a linear constraint of the monotonic data change reflecting the secondary fault condition in a quadratic programming problem.

40. The apparatus of claim 33 wherein the predictive trending mechanism includes at least one tuning parameter selected to achieve a desired tradeoff in noise rejection and data following performance for the estimated trend.

41. The apparatus of claim 33 wherein the performance estimator generates the performance parameter estimates for the mechanical system from sensor data residuals.

42. The apparatus of claim 41 wherein the performance estimator generates the sensor data residuals by using a predictive model of the mechanical system.